Project Report: Indigenous Bateria of Arctic and Antarctic Permafrost

Project Investigators: ***David Gilichinsky , James Tiedje***

Project Progress

The terrestrial permafrost provides and analogue of Martian subsurface cryogenic habitats and perhaps has genetic signatures of preexisting life or of viable cryo–adapted life. We isolated and characterized viable microbes from water brines sandwiched between Arctic permafrost strata. These 120,000–yr–old communities living at –10º C could represent Earth analogues of subsurface water brines that would be the only possibility for liquid water on present day Mars. Because of the relevance of this habitat for Martian life, we are currently having the genome of one of these isolates sequenced. F rom G laciogene Sirius Group permafrost deposits on Mt. Feather (Antarctic Dry Valleys), we isolated viable bacteria (aerobic and anaerobic, Gram–positive and Gram–negative), fungi, yeast, cyanobacteria, and green algae with an age presumably corresponding to the longevity of the permanently frozen soils estimated to be greater than 5 million years. This is the oldest, confirmed, viable microbial community in permafrost and living in conditions most similar to Mars. The viability of microbes frozen this long suggests that microbes can remain viable for the periods of time required for cryogenic meteorites to transit from Mars to Earth, i.e., confirms the possibility of panspermia. We also determined by phylogenetic analysis of 16S rDNA gene sequences from the permafrost, the composition of an Antarctic permafrost bacterial community. The most common sequences were of Proteobacteria but about 1/4 of the other sequences shared less than 80% similarity with those in the ribosomal database suggesting that they are novel genera. An important goal is to understand the strategy of biotic survival and adaptation in permafrost, and includes determining whether these microbes are active in this permanently frozen environment. We detected microbial activity as methane production in Arctic permafrost below 0ºC, and down to –28ºC (Fig. 1), indicating a type of unknown, chemolithotrophic, psychrophilic energy–producing biota that might be expected on cryogenic terrestrial planets free of oxygen.

Highlights

- Found a viable microbial community in >5 million year old Antarctic permafrost, to date, the oldest, confirmed, viable bacteria in a Martian analogue environment.

- Determined that longevity of life due to preservation within the terrestrial permafrost indicates that microbe viability can easily be preserved for the periods of time required to transport cryogenic meteorites from Mars to Earth.
- Described the biodiversity of indigenous, viable, halotolerant–psychrophilic microbial community in the water brines sandwiched in Arctic permafrost.
- Found biogenic methane production in Arctic permafrost of Holocene age incubated at subzero temperatures down to –28 °C, establishing that microbial processes can sustain life function at these temperatures.

Roadmap Objectives

- ***Objective No. 5.1:*** Environment–dependent, molecular evolution in microorganisms
- ***Objective No. 5.3:*** Biochemical adaptation to extreme environments
- ***Objective No. 6.2:*** Adaptation and evolution of live beyond Earth